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A PRELIMINARY STUDY

of the

CONTROL OF DENDROCTONUS MONTICOLAE (Hopk.)

on the

CACHE NATIONAL FOREST

A Thesis

By

Odell Julander

1931

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ACKNOWLEDGMENTS

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A PRELIMINARY STUDY OF THE CONTROL OF DENDROCTONUS MONTICOLAE (Hopk) ON THE CACHE NATIONAL FOREST

Introduction

The control of bark beetle in the pine forests of the United States has been carried on, to some extent, since 1905 when the first control measures were conducted against the Black Hills beetle in South Dakota(6)* and the mountain pine beetle near Colorado Springs in Colorado(7). During the last decade, this work has notably increased and in the last few years, enormous projects have been undertaken in the control of mountain pine bark beetle (Dendroctonus Monticolae) in the lodgepole pine forests.

The presence of mountain pine bark beetle on the Cache National Forest was known many years before effective control was undertaken. From 1923 to 1927, the rangers attempted to check the spread of the beetle through sales on the infested areas. In 1927 and 1928, limited control measures were made on certain areas by a small crew which worked on the sale areas, cutting and peeling the infested trees which were not merchantable. While this checked the increase in beetles to some extent, such limited control measures could not keep pace with the rising infestations which steadily increased.

Not until the spring of 1929 were appropriations available for extensive insect control measures. By this time the infestations had spread to practically every mature lodgepole pine stand on the forest north of the Utah state line. The project was begun in earnest that spring, but not until the following year was the magnitude of the problem fully realized. The timber destroyed during the season of 1930 by mountain pine bark beetle is estimated to be about 1,700,000 board feet. At present, insect control is secondary only to forest fire control.

*Figures in parenthesis, (6), refer to corresponding numbers in List of Citations.

Surveys were made on many of the national forests during the fall of 1930 to determine the effectiveness of the control of mountain pine bark beetle during the previous year and to make an estimate of the new infestations to be treated the following season. In making this survey on the Cache National Forest, it seemed advisable to summarize these data and point out certain factors affecting the control of mountain pine beetle as practiced on this forest, with the idea that it might, to some extent, be a possible index to the prospects of future insect control. In connection with the insect control projects, and in the study of the effectiveness of this work, it seemed desirable and important that a study be made of the number of new attacks resulting from infested trees escaping treatment.

Studies have been made along this line by A. L. Gibson (3) in the Big Hole Basin of Montana. In his study, the possible increase in new attacks was arrived at by determining the number of beetles emerging from infested trees and comparing this figure with the number of beetles which had attacked the tree studied. Such intensive methods of study were not used here and in this light, this may be considered as a preliminary study.

Since effectiveness of control and the number of new attacks resulting from trees escaping treatment are closely associated and greatly affect each other, they are both included in this study. The thesis, therefore, is divided into two parts as follows:

A. The Effectiveness of the Control of Dendroctonus Monticolae on the Cache National Forest.

B. A Preliminary Study of the Number of New Attacks Resulting from Infested Trees Escaping Treatment.

METHODS OF STUDY

I. Methods of Study of the 1929 Insect Control and Infestations

The effectiveness of the 1929 spring treating of beetle infested trees on the Cache National Forest was obtained from the actual treating records of that year and the year following.

The number of new attacks resulting from infested trees which were missed in the 1929 treating was studied in connection with the treating work during the spring of 1930. Small isolated infestations were chosen for the study to avoid, as much as possible, the chance of including in the study any new attacks of beetles from trees other than those which were counted immediately adjacent to the new infestations. The trees of these isolated groups of "red-tops" (trees which had been infested the previous year) were counted and the new strikes adjacent to them were recorded as they were burned by the treating crew. Only successful attacks were recorded. A one-hundred per cent cruise was made by the treating crew in their work and an accurate count, so far as the infested trees were distinguishable, was obtained.

II. Methods of Study of the 1930 Control and Infestations

The effectiveness of the 1930 treating was obtained from the burning records of that year, and by a survey which was made for the purpose of estimating the number of newly infested trees to be treated the following season. This survey also served as a means of study to determine the number of new beetle attacks resulting from trees which escaped treatment.

The Survey. The survey was made in September 1930 after the new attacks of the 1930 generation were made. Different methods were used in the survey. The line plot method was used on part of the area. Lines were run by compass and pacing and the trees were examined on 1/4 acre plots taken every 2 1/2 chains. The strip method was also tried, taking a strip a chain wide and examining all of the trees on this chain strip for infestations. The third method used was the same as the second except that the work

was done on horse back and the strips run at random in general directions. The distance was obtained by counting the paces of the horse. Each of these methods has its advantages and disadvantages.

In each case the lines were run on such bearings as would carry the estimater through the main body of timber. In this way, the estimater covered, as nearly as possible, what was considered an average of the stand. The bearing of the course was changed when necessary to stay within the timber, but in no case was the course diverted for the purpose of including small patches of treated or infested trees. On all strips and plots, all trees within the included area were inspected and the following data recorded: number of new attacks, number of infested trees missed, and the number of trees treated the past season. On two small patches of timber, which had been missed entirely by the treating crew, a more intensive survey was made by the parallel strip method to determine the ratio of increase in number of attacks on untreated areas.

A. THE EFFECTIVENESS OF THE CONTROL OF DENDROCTONUS MONTICOLAE ON THE CACHE NATIONAL FOREST

Presentation and Discussion of Data

Effectiveness of the 1929 Treating.

The standing-burning method was used in the control of mountain pine bark beetle on the Cache National Forest. The spotting and treating was done in one operation by the treating crew. Infested areas were scouted out and an effort was made to clean up all of the infested trees. The treating crew stripped the infested stands in a more or less unorganized formation, burning the trees as they spotted them.

The infestations were widely spread and in a rising epidemic stage on most of the lodgepole areas of the main division of the Cache Forest in Idaho. As a rule, the mature and decadent stands were attacked most heavily, but many thrifty immature trees were also successfully attacked.

The 1929 treating was far from being successful as shown by the following table.

Table 1. Showing the increase in number of infested trees. from 1929 to 1930.

Trees treated in 1929	Trees treated in 1930	Percentage increase
11,277	17,158	52.15

This table does not indicate the true rate of increase because all of the infested trees were not treated in 1929. It was thought that about 2,000 of them were left on untreated areas. If we add this to the number of trees treated, the increase from 1929 to 1930 would be 29.23 per cent. This represents more closely the true rate of increase. However, it may still be high because more trees were missed by the treating crews on the areas covered in 1929 than in 1930.

The unsatisfactory results of control measures during 1929 are plainly understood. The magnitude of the project was not fully realized. The work was organized on the basis of treating about 3,000 or 4,000 trees which was the estimated number. With this size of organization, the work could not be completed before fire season arrived. It was estimated that on untreated areas, about 2,000 infested trees remained at the time the treating crews were forced to discontinue their work. These untreated infestations account for part of the increase.

Another cause of the unsuccessful results was the lack of proper organization of the treating work. The infested areas were scouted and stripped by the treating crew in unorganized from without making a systematic cruise of the timber by following compass lines. As a result, groups of infested trees, as well as scattered trees, were missed.

The other major cause of the unsuccessfulness of the 1929 treating was that the amount of burning necessary to destroy the insects was not fully understood. Many of the trees were not burned enough and the trees which were attacked to considerable height were not burned high enough. Examinations which were made the following year, showed that the beetles had emerged from many lightly burned trees and from the tops of trees which had not been burned high enough. Beetles from these trees and the numerous infested ones escaping treatment, account for the increase in infested trees from 1929 to 1930.

The poor results of the 1929 treating showed the necessity of a one-hundred per cent cruise in the treating work and the importance of burning every infested tree thoroughly.

While the control measures of 1929 were unsatisfactory, they cannot be considered entirely ineffective. No doubt the 1930 infestations would have been much greater had no control measures been taken in 1929.

Effectiveness of the 1930 Treating.

As shown by Table 1, there was a large increase in the number of beetle infested trees from 1929 to 1930. The infestations were more widely spread and in a seriously rising epidemic stage. The trees were as heavily infested and the attacks extended to as great a height as those of the previous year. In only a few cases had the infestations been noticeably checked.

The trees were treated by the standing-burning method as in 1929. The work was better understood and the importance of making a one-hundred per cent clean up of infested trees was more fully realized than it had been in the past year. The spotting and burning was done in one operation and the work was organized with the idea of making a one-hundred per cent cruise of all infested lodgepole areas. Extension rods were used on the pumps when necessary to reach the full height to which the attacks extended and special care was taken to treat every infested tree thoroughly.

Table 2 shows the effectiveness of the 1930 treating as determined by the treating records of that year and the survey of the infested areas which was made in the fall of 1930.

Table 2. Showing the effectiveness of the 1930 treating.

No. Trees Treated in 1930	Estimated No. of Trees to be treated in 1931	Degree of Effectiveness of the 1930 Treating
17,158	6,365	63 %

This table shows the 1930 treating to be 63 per cent effective. The estimated number of infested trees for 1931 is but 37 per cent of the number of trees treated in 1930.

The results of the insect survey shown in table 6, give 6.38 burned trees for every new attack found. This indicates that the 1930 treating was

more than 63 per cent effective. Another indication of this, is the fact that over 9 per cent of the 1930 treated trees were found on the plots of the 5.15 per cent survey as may be seen from Table 6. This may indicate that the survey lines were run through the areas which were heavily infested in 1930. Whether or not the survey represents better than an average for the new infestations is not certain.

The effectiveness of treating on individual areas cannot be determined because the number treated was not recorded separately for the different units. The degree of effectiveness varied somewhat. On three small areas which were not heavily infested, a one-hundred per cent clean up was made.

The success of the 1930 treating may be accredited to: (A) a one-hundred per cent cruise of infested areas by the burning crews, (B) the thorough treatment of every infested tree found, and (C) a good organization composed, for the most part, of experienced men.

The survey made during the fall of 1930, showed that the infested trees which had been missed, were very scattered. No groups of infested trees had been missed except in two small isolated patches of timber which had been overlooked entirely by the treating crews. No emergence holes were noticed on any of the burned trees and the absence of woodpecker work in the tops of the trees, indicated that the beetles had been successfully destroyed there also. Apparently, the source of the beetles of the new attacks was almost entirely from trees escaping treatment.

Table 4, giving the results of the insect survey, shows that 3 per cent of the infested trees of 1930 had been missed by the treating crew. Examinations of these missed trees gave explanations why most of them were passed up. The chief cause for missing trees seemed to be that many infested trees showed no pitch tubes, and entrance holes were very obscure. In the spring of the year, such trees were very difficult to pick out as being infested.

Other infested trees had been tested by burners and passed up as being pitched out. Trees passed up in this way were partially pitched out and showed emergence holes only on one side or on a small portion of the bole. Donald De Leon, in his studies of emergence and sex ratio of mountain pine bark beetle in white pine (1) shows that a large number of attacking parent beetles emerge after their first attack. Many infested trees showing numerous emergence holes were noticed on the Cache Forest in 1930 treating work. In some of these trees, the larvae were fairly large and numerous and when they were examined, there was no question as to whether or not they were infested. Others however were questionable. In some, the larvae were small and few and the bark appeared rather dry. Such trees, with their numerous emergence holes, had the appearance of those attacked the previous year. These emergence holes in the infested trees were not understood at that time and it is quite probable that a considerable number of trees were passed up in this way. The possibility of missing infested trees by slack organization of the burning crews, and by employing men who are not continuously alert and reliable, is always present.

These observations show the necessity of an efficient organization of trained men and indicate the desirability of burning all doubtful trees along with those known to be infested.

Possibilities of Future Insect Control.

The prospects of future control of mountain pine bark beetle on the Wache National Forest, look very favorable. The present infestations which are to be treated in the spring of 1931 are, for the most part, well broken up. Infested trees are very scattered. Usually, only from two to five infested trees are found in a group. The infested trees are not attacked nearly so heavily as those of the 1929 and 1930 infestations. Trees were rarely attacked above twenty-five feet and the average height to which the

attacks extended was about ten to fifteen feet. Many trees were attacked only on one side. Some of these light attacks appeared to be succesful, but some of them were thoroughly pitched out. Occasionally, a tree was attacked by ten to twenty, or even fewer beetles. In such cases, the beetles were washed out by a very heavy flow of pitch. There was a larger percentage of unsuccesful attacks this year than in the two previous years.

In general, the infested trees to be treated in 1931 can be spotted much more readily than many infestations of 1929 and 1930 because the trees, being attacked more lightly produced a heavier flow of pitch. This should aid materially in the effectiveness of the 1931 treating work. The fact that the attacks, in general, expend only a comparatively short distance up the tree, will make thorough treating much easier and less expensive. Most of the infested trees can be treated thoroughly without the aid of extension rods on the pumps. Few, if any, trees will need to be felled for proper treating. It is believed that even the highest attacks can be successfully treated by the use of extension rods on the pumps.

Hopkins, in his studies of Mountain pine beetle, (5) states that in case of a destructive outbreak, it is necessary to destroy only from 50 to 75 per cent of the beetles in order to bring them under complete control. When only 25 to 50 per cent of the beetles remain, they are placed in a defensive position against their natural enemies and are forced to live upon weakened and felled trees. In this light, it would appear that the beetles are now under complete control on the Cache Forest. If the survey of the fall of 1930 may be relied upon, there are only 37 per cent as many infested trees for 1931 as there were in 1930 and since the new attacks are much lighter, over 63 per cent of the beetles have been destroyed. Whether or not this would put the beetles under complete control is very doubtful. De Leon (2) in his studies of the parasites and predators of mountain pine beetle, states that the

treatment of infested trees after the middle of May, destroys practically all of the beneficial insects along with the beetle brood. Since most of the treating was done after May 15th on the Cache Forest, a large percentage of the natural enemies was probably destroyed. Another factor which would favor the increase of the remaining beetles, is the large number of weakened and partly dead trees left in the forest as a result of previous treating operations.

Under such favorable conditions, it would probably be unsafe to consider that the insects were under complete control when only 75 per cent of them had been destroyed. However, it seems reasonable to expect that after another year of treating, such as was practiced in 1930, the infestations on the Cache National Forest will be well broken up and can be kept under control with a small amount of localized treating from then on, provided no increase from foreign infestations occurs.

B. A PRELIMINARY STUDY OF THE NUMBER OF NEW ATTACKS RESULTING FROM TREES ESCAPING TREATMENT.

Study of Increase from 1929 to 1930.

Table 3 gives the ratio of increase in attacks from four small infestations. This study showed that for every tree missed in these groups in 1929, there was an average of 4.32 new attacks found the following year. This study is very meager since it includes only four small isolated groups of infested trees. These isolated groups were chosen for study to avoid, as much as possible, the possibilities of increase in attacks from beetles of infested trees other than those included in the study. Even in these small infestations there is some possibility of beetles drifting in from outside areas. Little is known about the flying ability of the beetle, but no doubt

Table 3, Showing the number of new attacks resulting from infested trees escaping treatment in 1929.

Patch Number	Location	Infested Trees Burned in 1929	Infested trees missed in 1929	Infested trees found in 1930	Ratio of increase
1	North Canyon	18	8	35	1 to 4.37
2	Eight Mile	0	36	125	1 to 3.38
3	Skinner Creek	24	7	36	1 to 5.14
4	Skinner Creek	30	5	22	1 to 4.4

Average ratio of increase, 1 to 4.32

it could have reached these patches from other infested areas which were not far distant. However, it appeared as though the new attacks studied resulted from the groups of red tops immediately adjacent. Patches number 1, 2, and 4 were in mature lodgepole timber on north slopes and in each case, the new attacks were immediately below the red tops and in a strip extending in a northeasterly direction for a short distance. Patch number 3 is a small isolated patch of timber with an area of about 30 acres. It appeared that this infestation

patch rather than from beetles drifting in from other areas.

Along with the question of the possbbility of insects drifting into the patches studied, comes the possibility of the beetles of the trees studied, drifting out. There is no check upon either of these possibilities, but judging from the character of the infestations studied, it seems that these factors do not seriously interfere with the particular groups considered. Another factor influencing the ratio of increase in attacks would be the distance of flight and the flight loss. Since in the infestations studied the flight was very short, it is probable that the flight loss was very low.

The ratio of increase from trees escaping treatment in the groups studied may not hold true for all of the infested areas of the Cache Forest. Whether or not the ratio of increase would be the same for large infestations as for small ones is questionable. However, patch number 3 had by far the largest number of infested trees in it and showed the smallest increase in attacks. It will also be noted that this patch received no treatment in 1929. Whether or not this affects the ratio of increase in attacks is not certain. This study is too limited to arrive at any definite conclusion on this question. In the fall of 1929, rangers of the Cache Forest roughly estimated that there were from five to ten new attacks for every infested tree missed. Their minimum figure was probably high enough for any of the infested areas.

Both new and old attacks were very heavy in all four patches studied. In all of the attacks of the previous year, the beetles had succeeded in completely killing the trees. While this study is very limited and may not apply to all infested areas on the Cache Forest, it is believed to be a fair index to the average ratio of increase in attacks on this forest from 1929 to 1930.

Study of Increase from 1930 to 1931.

Most of the heavily infested areas on the Cache Forest were included in the study of the number of new attacks resulting from trees escaping treatment in 1930. All of the areas in Table 6 which have complete data recorded were included in the study. Areas other than these were surveyed by different

parties and were not included. These areas, however, seemed to show no marked variation from those studied.

Table 4 shows that for every tree missed in 1930, there were 5.10 new attacks that fall. This is an average of the areas studied which had been treated in 1930.

Table 4 . Showing the number of new attacks resulting from infested trees escaping treatment in 1930*

Areas burned on plots in 1929	Trees missed on plots in 1930	New attack on plots	Ratio of increase from 1930 to 1931	Per cent of infested trees escaping treatment
1627	50	255	1 to 5.10	3 %

As explained under the effectiveness of the 1930 treating, the attacks of that year were very heavy and extended to considerable height while the attacks resulting from missed trees of that year were mostly very light and extended to an average height of about 10 to 15 feet. Since the attacks were much lighter than those of the previous year, the ratio of increase in number of attacking beetles was much less than the ratio of increase in infested trees. Many of the newly attacked trees recorded will probably not be killed by the beetles but only weakened. Only attacks which were thought to be successful were recorded in the survey, but it is possible that some of the lighter attacks will be pitched out before the 1931 burning season. From these observations, it seems obvious that the number of trees actually killed by beetles from missed trees will be somewhat less than the number of attacked trees recorded.

* Based on area covered in the 5.15 per cent cruise made in the fall of 1930 on previously treated areas. This includes only the main survey in which the above data were collected as shown in Table 6 minus the two areas in Table 5.

The ratio of increase in new attacks of 1 to 5.10 for 1930 to 1931 compares favorably with the ratio of 1 to 4.32 for the increase in attacks from 1929 to 1930. The ratio of increase in newly attacked trees is greater from 1930 to 1931 but the ratio in number of beetles per tree is much less.

There was a decided tendency for the beetles from scattered trees which had escaped treatment, to attack weakened and diseased trees. Where enough beetles were attacking, thrifty trees were attacked as was the case in the 1929 and 1930 infestations. Where the attacks were light, they were often made on weakened and diseased trees.

As shown by Table 6, the average cruise of the previously treated areas studied was about 5.15 per cent. A more intensive cruise would be desirable for more accurate information. No doubt the estimates were too high on some of the areas and too low on others but it is probable that these would balance to some extent and that an average over the entire area studied may be a fair estimate.

Study of Increase on Untreated Areas.

The study of the increase in new attacks on untreated areas is very limited. It includes only two small patches which were the only untreated areas found in the insect survey. These are the only areas known to have been overlooked in the treating work of 1930. Table 5, giving the results of the survey, shows that the ratio of increase on one of these areas was 1 to 1.30

Table 5, Showing the ratio of increase in new attacks on untreated areas.

Location of area	Acreage of area	Per cent cruised	1930 attacks on plots	New attacks on plots	Ratio of increase
Forks at North Canyon	70	35.28	17	22	1 to 1.30
Eight Mile Canyon	29	14.65	11	42	1 to 3.82

Average ratio of increase, 1 to 2.29.

and 1 to 3.82 for the other with an average ratio of 1 to 2.29. The Eight Mile Ridge patch was mature timber and the North Canyon timber was somewhat younger. This may partially account for the difference in ratio of increase since the younger trees have more resistance to attacks than older ones. However, many other factors may enter in, such as the presence or absence of weakened and diseased timber, number of natural enemies, exposure and altitude, etc.

Here, as in the studies of the previous year, we have the possibility of beetles drifting in or out of the areas studied. To what extent this may be is unknown.

By comparing Table 5 with Table 4, it may be seen that the ratio of increase in new attacks is smaller on untreated areas than on areas previously treated. The average ratio of increase on previously treated areas in 1930 to 1931 was 1 to 5.10 while on the untreated areas it was only 1 to 2.29. Also, in Table 3 of the 1929 to 1930 studies, patch number 3, which was the only patch studied that had not received treatment in 1929, had the lowest ratio of increase in new attacks. From these observations, it seems that the control measures raised the ratio of increase, but not the actual number, of trees attacked. Gibson, (3) in his studies of bark beetle in the Big Hole Basin, also observed that the control measures of 1928 raised the percentage of trees infested. He accredited the increase in perdentage to beetles immigrating into the area from other infestations. It is the writer's belief that this is not the case on the Cache Forest. It seems probable that the reason for the greater ratio of increase in new attacks on previously treated areas on this forest is due, in part at least, to the destruction of the natural enemies of the bark beetle in the treating work and to the large amount of weakened and partially dead timber present on treated areas. The destruction of the natural enemies would probably be the greatest factor. The large amount of weakened timber would be favorable for the increase of the beetles and it would

take fewer beetles to make a successful attack upon these trees. There is some possibility that beetles emerging from poorly treated trees may cause a slight increase in number of attacks on previously treated areas but this is believed to be small or negligible on the Cache Forest.

The attacks on the untreated areas studied were heavier and extended to a greater height than the attacks on previously treated areas. It is probable that the actual ratio of increase in attacking beetles was about as great on untreated areas as on treated areas because of the greater number of beetles per tree.

These studies show a high ratio of increase compared with studies made by Gibson in the Big Hole Basin (3). He states that the number of beetles emerging could hardly cause the out break to increase as much as 100 per cent. De Leon (1), in his study of sex ratio, states that the beetles emerging and making a second attack might increase the number of attacks 47 per cent.

It might be possible that beetles have immigrated to the Cache Forest from neighboring forests during the years of these studies and, in this way caused errors in theestudy of the ratio of increase in new attacks from trees escaping treatment. However, this does not seem to be the case. It is believed that the infestations on the Cache Forest have been built up by increase of local beetles rather than by extensive immigrations from other infestations.

The results of these studies probably apply only to the Cache Forest and for the years in which the studies were made. More intensive studies are necessary along this line. It is hoped, however, that this will throw some light upon the ratio of increase and the prospects of future control of mountain pine bark beetle.

Summary and Conclusions.

1. The number of infested trees increased from 11,277 in 1929 to 17,158 in 1930, an increase of 52.15 per cent.

2. Causes of increase: (A) the project was too large for the organization and the work was not completed. (B) inefficient organization of treating work resulting in numerous missed trees. (C) the amount of burning necessary to destroy the insects was not realized and trees were poorly burned.

3. A one-hundred per cent cruise and thorough treating of every infested tree is necessary for effective control.

4. The 1930 treating was 63 per cent effective or better.

5. The success of the 1930 treating may be accredited to: (A) a one-hundred per cent cruise of infested areas, (B) thorough treatment of every infested tree found and, (C) a good organization composed, for the most part, of experienced men.

6. The source of beetles which made the new attacks of 1930 to 1931 was almost entirely from missed trees. Very few beetles emerged from treated trees.

7. About 3 per cent of the infested trees were missed in 1930. Causes for miseing trees: (A) absence of pitch tubes and obscurity of emergence holes, (B) testing and leaving trees which were only partially pitched out, (C) passing up trees which showed emergence holes of beetles which had emerged to make a second attack.

8. All questionable trees should be treated along with those known to be infested.

9. Possibilities of future insect control on the Cache Forest seem very favorable. The infested trees are scattered and the new attacks are much lighter than before.

10. The ratio of increase in new attacks from 1929 to 1930 was 1 to 4.32.

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9. Possibilities of future insect control on the Cache Forest seem very favorable. The infested trees are scattered and the new attacks are much lighter than before.

10. The ratio of increase in new attacks from 1929 to 1930 was 1 to 4.32.

11. The ratio of increase in new attacks from 1930 to 1931 on previously treated areas was 1 to 5.10.

12. The ratio of increase in new attacks on untreated areas studied was 1 to 2.29. The attacks on untreated areas were heavier than those on previously treated areas.

Table 6 Showing Results of the 1930 Insect Survey

Location of unit	Infested trees missed 1930 On plots	Newly infested trees on plot	Total No. of infested trees on unit	Area of plots	Total area of unit	No. of infested trees per acre	1930 burned trees on plots	Per cent cruised
Eightmile - Cheatbeck	7	58	1169	3450	1313	.89	107	262
Skinner-Pearl - Coop Cr.	13	64	1120	95.75	2139	.52	495	4.47
North Stauffer - Beaver	6	26	230	2950	276	.83	214	10.69
South Stauffer	1	7	126	16.50	297	.43	39	5.55
North Canyon - Fern Cr.	13	65	977	90.25	1208	.81	374	7.47
Upper Williams Cr.	3	6	125	14.00	290	.43	29	4.83
Emigration Canyon	2	10	190	27.00	654	.29	125	4.13
Pole Canyon	1	2	21	8.00	85	.25	56	9.41
Upper & Lower Gulley	4	17	241	31.50	557	.43	188	5.66
Sub Totals	50	255	4199	351.25	6819	.62	1627	5.15
Forks of North Canyon	17	22	63	2470	70	.90	0	35.28
Cow Fork Ridge	11	42	290	4.25	29	10.00	0	1465
Totals for areas not included in study	Not recorded		1813	----	11466	.16	not recorded	
Totals			6365		18384	.346		

Plate 1. Showing the standing-burning method of treating trees.

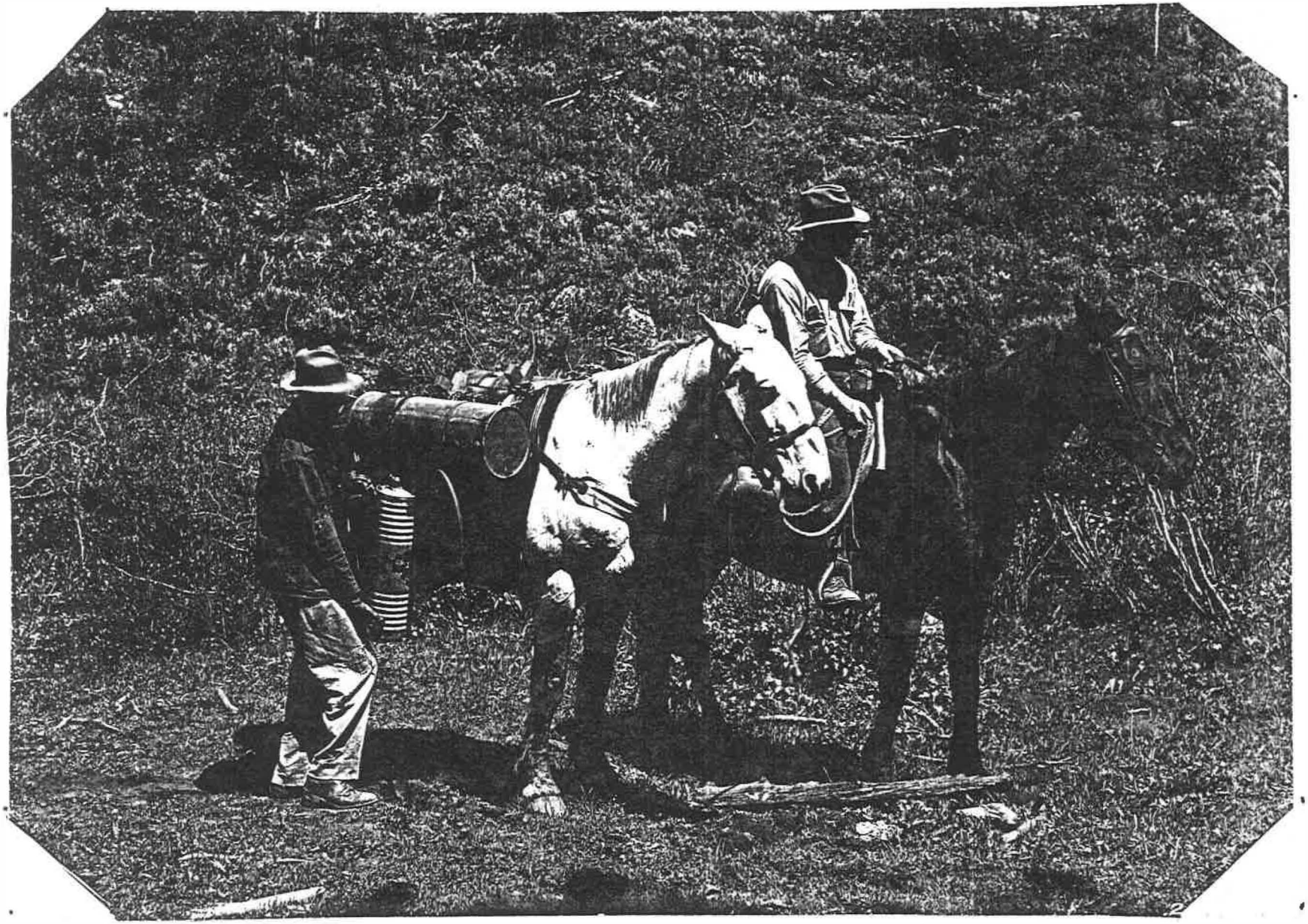

Plate 2. Showing method of conveying oil to the burners.

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